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Technical Report ARAED-TR-93002

PRODUCT IMPROVEMENT PROGRAM 1-84-09-7133  
25 mm METAL PA 125 CONTAINER

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June 1993



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13. ABSTRACT (Maximum 200 words) The initiation of the PA125 metal container program was to alleviate the deficiencies of the current plastic 25 mm M621 container in the areas of seal capability, structural integrity and flammability problems. The PA125 was designed to meet the current military packaging requirements including the ability to maintain a 3 psi seal after rough handling throughout the temperature extremes of -65° to 160° F. In addition, the container was designed to interface with the stowage system of the Bradley fighting vehicle system. The design effort for the PA125 consisted of the redesigning of the internal system and the metal container with a removable cover. Because of the vehicle interface requirement, the internal support has to house two 15-round belts of ammunition in a very tight configuration. Extensive engineering evaluation was conducted throughout the program to insure the most efficient nesting configuration for conserving space while still providing excellent protection for each cartridge during rough handling. The container demonstrated excellent performance during the qualification test program managed by TECOM and evaluated by AMSAA. The program objectives have been accomplished successfully and the container is well received by the Army. Implementation of the PA125 has been initiated for the the M910, M791, and M793 buys starting in FY93 to phase into the 25 mm ammunition while the M621 container will be gradually phased out of the system.				
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## INTRODUCTION

### Background

During early 1980, the M621 plastic container was developed for the BFVS (fig. 1). The container was fabricated with 30 percent glass-filled polypropylene. For increased strength to support the weight of the cartridges, the internal plates were fabricated with a glass-filled nylon, Zytel (manufactured by Dupont). The container housed two 15 round belts in a nose-to-nose orientation. The container was designed with two covers so that the belts must be extracted from each end of the container.

Shortly after the fielding of the M621 container, deficiencies such as marginal sealing capability and difficulties in accessing the ammunition were found. The container could only hold a 1 psi seal. Once the container was opened, it would not be able to be resealed due to the compression set of the gasket. Because of this, M621 containers with the covers opened had to be shipped to the ammunition manufacturer for packing. The container also performed poorly in cold temperature drops. In a live fire test conducted with the Bradley fighting vehicle, the concern of flammability and toxicity associated with all plastic packaging was raised for the survivability of the BFVS personnel during a combat scenario. Furthermore, the wooden frame used on the pallet to protect the M621 containers breaks apart easily in shipment resulting in high maintenance costs.

As a result, ARDEC initiated a product improvement program in 1984 to alleviate the above deficiencies of the M621 container.

The program was initially targeted to improve the existing plastic design but very quickly the plastic design was proven to be a wrong approach. The redirection of the program to a metal with plastic internal support design was decided as a result of the plastic failure. The program was planned and executed in these four phases: the engineering development, prototype fabrication, qualification testing, and implementation.

During the middle of the program, it was changed from product improvement program (PIP) to materiel change (MC) program. TECOM was the overall test manager and AMSAA was the independent evaluator. The MC program was completed successfully according to the plan. At the present time, the implementation of PA125 is in progress for the M910, M791, and M793 cartridge procurements.

## **ENGINEERING DEVELOPMENT**

### **Plastic Design**

The development of the improved plastic container design was initiated at the start of the PIP program. A contract was awarded to Environmental Container Systems, Inc., Oregon to design develop and fabricate a plastic container for 25 mm ammunition. After reviewing the deficiencies of the M621 container, a side-opening container with center hinges was developed ( fig. 2). Instead of polypropylene, a 30 percent glass-filled sheet molding compound (SMC) was selected for increased impact strength. The container was fabricated by compression molding. Injection molded polycarbonate was used as the internal support for the two belts of cartridges.

The container demonstrated excellent impact characteristics during the initial testing. However, the internal support failed when cracking was found after the 3-foot drop tests, and leakage was also experienced in the seal area. After further evaluation, this approach was terminated due to the following reasons:

1. The side-opening closure could not provide sufficient forces to hold a 3 psi seal. Although the SMC was more dimensionally stable, the hinge and latch closure (similar to the M621 container) resulted in two different forces in the closure mechanism (tensile at the hinge and compression at the latch), thus creating a nonuniform sealing surface.

2. SMC material was three times as expensive as the thermoplastic such as polyethylene. In addition, the processing cycle required a much longer time for the resin to polymerize in the mold. This concept was not cost-effective.

### **Improved Gasket Design**

After the termination of the above effort, Arrundale Inc., the company involved in the initial M621 container production, proposed a gasket improvement for the current M621 container design. The changes included a metal reinforced cover and a solid gasket instead of the hollow gasket used in the M621 container. Before pursuing this effort ARDEC conducted an in-house leaking test with a molded gasket design. The molded gasket, with a softness of 40 durometer, eliminated the vulcanized joint for improved sealing surface. A large sample of M621 containers was obtained from Kentucky Blue Grass Army Depot where M621 containers were renovated. A leak test was conducted with a new molded gasket using the containers. In addition, a control test was conducted using the new M621 hollow gaskets.

The results showed that the average seal for the control containers was 1 psig and 1.5 psig for the molded gasket design. It was determined that this improvement was not significant. The containers were then subjected to a second series after they were opened and reclosed several times. As a result, the seal dropped below 1 psig for both gasket designs.



The conclusion of this evaluation was that the deficiency was due to the closure design rather than the gasket design. As indicated in the initial SMC container effort, the hinge/latch design problems were very difficult to overcome especially with plastic materials even when the covers were reinforced with metal.

## **Metal Design**

With the lessons learned, the program was redirected in 1988 to avoid using plastic as primary packaging. A metal container (low carbon steel) was developed based on the M548 style of container. The M548 is a long established metal container developed to ship 20 mm ammunition. The double-end opening covers were replaced by one removable cover which consisted of two latches for improved sealing. Because of the metal design, a separate internal support system was developed. The initial prototype was designed with SMC to provide the protection for the two belts of cartridges. The support was fabricated by compression molding followed by a secondary drilling operation for the hole pattern. The hole pattern for housing the cartridges had to be modified because of the metal container design.

Upon the completion of the prototype, the initial testing was performed with foam pads placed at the top and the bottom of the container to insure a tight pack. The test results showed that both the container and the internal support system had to be improved. The corner of the container cracked after the drop test indicating that the material was not strong enough to take the loading. After the secured cargo vibration test, extensive abrasive damage was found in the tips of the M794 (dummy) cartridges.

The next iteration of testing was conducted with an improved version of the metal container which was fabricated with high strength low alloy (HSLA) steel. HSLA steel provided more strength compared to the previous low carbon steel design. To correct the above cartridge interference problem, a plastic restraining plate was designed to replace the foam pads. After the vibration test, a problem was found between the big hole no. 5 and small hole no. 11 where the tip of the projectile rubbed against the link tab of the opposing belt of cartridge (fig. 3 ). Due to the use of the dummy rounds in the testing, it was unsure what effect this would have on the fuzed M792 cartridges.

To evaluate the above problem further, an engineering test series (preliminary rough handling, TECOM Project No. 1-ES-400-621-005) was conducted at Combat Systems Test Activity (CSTA), APG in 1989 using M792 and XM881 cartridges (an early version of M919). The tests consisted of secured cargo vibration, 3-ft drop tests, loose cargo vibration, and 7-ft drop tests. The test results showed that the same interference occurred after the secured cargo vibration test at the same two locations of the internal support. The interference caused severe gouging to the fuzes of round no. 11 (both sides) by the link tabs of round no. 5 (both sides) and the rounds were determined to be unsuitable for the firing tests. Some protective caps on the XM881 cartridges were found damaged as a result of the above rough handling tests.

## **Improved Internal Support**

After the evaluation, the hole pattern was reviewed in detail for improvements. With the help of Autocad computer software, the entire hole pattern was modified to allow more isolation for the tip of the projectile (figs. 4 and 5). A belt of new M794 dummy cartridges with new M18 links was pulled apart and pressed together to determine the acceptable worse case tolerance with reference to the support plate hole displacement. New links were selected in order to give a worse case since older worn links would be more likely to separate easier. The individual cartridges were also twisted at various angles to determine the effect on this round to link to cartridge separation distance.

The above information was entered into the 3D computer model for further analysis. Keeping with the similar hole pattern as used in the M621 container and the earlier PA125 designs, the new modified design skewed the no. 11 cartridge away from the problem link of cartridge no. 5 of the opposing belt of cartridges. The skewing was based on the boundary conditions established from the worse case stretching and twisting of new links in conjunction with the problem link stated above. This occurred along the axis of the link chain and no other links were affected. Additional modeling determined that the separation distance between the opposing belts of cartridges could also be reduced hence, a shorter version of the internal support was developed for evaluation. The shorter support system would nest the cartridges closer therefore allowing more space for cushioning and/or a shorter container for better stowage interface with the Bradley vehicles. The interface with the vehicle will be discussed in detail later in this report.

Taking advantage of the separator design in the M621 container, the top and bottom plates are also interchangeable. Therefore only one mold design will be required. In high volume production, multiple mold cavities with the same design would be used for high efficiency.

An additional problem was observed in the M621 hole placement that was easily corrected in the new PA125 support system. In folding the belt of cartridges, it was observed that a portion of the link attached to cartridge no. 4 was in fact gouging into the cartridge case of the cartridge no. 7. In normal handling and more so, in rough handling, most no. 7 cartridges were found to have some degree of this gouging. The design improvement was to move the no. 4 cartridge 0.080 in. closer to the no. 15 round. This eliminated the gouging problems completely.

The final improvement was to incorporate a 45 degree chamfer at the entry of all the big holes for ease of cartridge extraction, particularly with the M791 cartridges.

An engineering test program was conducted at APG with a regular support and a short support in August 1989 under the same TECOM project conducted in 1988. The hole pattern of both supports was modified as discussed above. The test results were very successful. However, some minor abrasion between the projectiles was

found in the shorter support. As a result, this version was not recommended by the tester.

The same damage occurred in the plastic protective caps of the XM881. This was determined to be due to the design deficiencies of the cap. The material and/or molding process and the locking design were recommended to the 25 mm ammunition engineering group at ARDEC for further improvement in this area.

Finally, the design of the hole pattern of the center support was completed based on the data generated from the engineering studies and testing. The significant improvements are as follows:

1. Big hole no. 11 and its corresponding small hole were pivoted 6 degrees off its normal center line as compared to the other 14 cartridges to skew the tip of the projectile away from the link tab of the opposing belt. The skew was oriented 24 degrees off the center line of the length of the plate (fig. 3) so as not to cause any undue wear to the link train connecting cartridges 10, 11 and 12. This would alleviate the abrasion problems encountered in the previous engineering tests.

2. A 45 degree chamfer was incorporated into the big holes for ease of cartridge extraction.

3. The gouging problem existing in cartridge no. 7 in the M621 container was eliminated.

4. In addition to the four corner posts, two center posts were added to increase the strength for supporting the belts of cartridges.

### **Final PA125 Design**

Following the successful engineering evaluation, the final design of the metal container was developed and designated as PA125 container for 25 mm ammunition. The technical data package (TDP) was prepared for procurement of prototypes for the qualification program (app A). The container contract was awarded to Sverdrup Corporation at National Space Technology Laboratory (NSTL, now Stennis Space Center) and Kisco was used as subcontractor for the fabrication of the PA125 containers. The internal support system which consisted of a center support, top and bottom restraining plates and foam fillers was further studied in this phase for implementation into BFVS.

The SMC approach evaluated in the previous phase had some disadvantages for large volume production although SMC performed extremely well in protecting the cartridges. The holes on the center support plate could not be molded all the way through by the compression molding process because of the fiberglass laminates. Therefore, a secondary drilling operation would be required. Because of the extreme hardness of the SMC, drill bits wore out easily. Furthermore, extra precaution had to be taken to handle the fiberglass dust generated in the operation in order not to

jeopardize the health of the operators. The overall SMC support was also not cost-effective. However, since this design had been proven, the SMC support was planned as a back-up design in the qualification test series.

Nylon 6/6 resin was then evaluated to replace SMC. Zytel (Dupont's trade name for Nylon 6/6) which was used in the M621 as separator was selected for the center support design. Zytel is a nylon resin filled with 30 percent fiber glass and can be injection molded. The impact strength and temperature properties are excellent for this application. Injection molding process was also selected for the end restraining plate. Because of less demand for structural support, foamed filled olefin was selected for weight reduction. In order to make a tight pack, a synthetic foam rubber was selected as the material for the foam filler.

The contract for the internal support system was awarded to NDI as a task order contract. Polymer Technologies, Inc. was used as subcontractor for the fabrication of the prototypes.

The final PA125 container design as depicted in figure 6 offers the following outstanding features:

1. Excellent sealing capability - The double latch design of the container provides a uniform compression of the gasket for achieving the sealing requirement of 3 psig. The wide gasket design allows the container to be easily resealed. A sealing test conducted in April 1991 demonstrated this excellent characteristic repeatedly.

2. Extreme ruggedness - Constructed with HSLA steel with improved strength to weight ratio, the durability of the container will be enhanced throughout the logistic cycle hence reduce maintenance costs.

3. Superior internal support system - The well-designed system provides the most efficient nesting configuration for the two 15-round belts thereby conserving space while still providing excellent protection for each cartridge during rough handling.

4. Excellent handling capability - The single-end opening cover allows quick and easy access to ammunition in the tight confines of the Bradley vehicle. The wide handles provide one-man portability even when wearing cold weather gloves.

5. Excellent producibility - The container and the internal support system can easily be produced by current established metal fabrication technology and plastic molding processes economically.

## **PROTOTYPE FABRICATION**

### **PA125 Container**

As discussed earlier, the PA125 containers were fabricated by Kisco at St. Louis. Kisco and Standard Container are the two companies with extensive experience in manufacturing of the PA125 style of container for the Army. Kisco had encountered some problems in the tooling in handling the stronger HSLA steel because it did not meet the tolerance requirement. The problems were mainly due to the higher tensile strength causing difficulty in the folding operation. After the adjustment of the tooling, the 1500 prototypes were fabricated and delivered to the Government.

The tooling developed under this contract was nonhardened which can only be used for fabrication of a limited quantity of prototype containers. Some of the tooling can be modified and used for production should Kisco get involved in the future production. In addition to the PA125 container program, the tooling developed under this program was also used in the development of the PA155 and PA156 containers for the 81 mm mortar ammunition. Both containers are longer than the PA125 and were successfully fielded.

### **Injection Molded Internal Support**

The injection molded internal support effort was tasked to Polymer Technology Incorporated (PTI) by the prime task order contractor, NDI. PTI had numerous government programs for producing injection molded parts. The significant programs involved with the Packaging Division in the past five years included the plastic 81 mm mortar container. The support system including the restraining plates and the center support designed by this Division was provided to PTI for review. The mold design for the restraining plate was rather straightforward because of the looser tolerance allowed for these parts. However, the center support required much tighter tolerances to ensure the cartridges received protection during rough handling. PTI initially conducted a shrinkage trial-and-error for the mold design. In addition, injection gate designs were also evaluated to ensure the uniformity of the glass content in the molded part. As a result, a disc gate which allowed molten resin to be injected through the entire length of the plate was selected for this purpose.

The first trial showed that the gate selection was successful but the shrinkage was not achieved as predicted. Therefore, the mold was modified to compensate for the shrinkage. After several runs, the parts molded were within the dimensional tolerances. The final step was the assembly of the molded parts to form the center supports. The support rods can be glued or welded to the plates. For higher production efficiency, a welding process would be more appropriate compared to using glue. Ultrasonic welding was evaluated to assemble the center support and the results were very satisfactory. In order to maintain the alignment of the holes for the top and bottom plates, a fixture was used to secure the position of the plates during

welding. As a back-up for the injection molded support, PTI was also tasked to fabricate the SMC supports and these parts were delivered to ARDEC. These parts were not needed in the PQT as the injection molded supports performed very well in all testing.

### **PA125 QUALIFICATION PROGRAM**

After the successful in-house effort for the development of the PA125 container program, the container was subjected to a series of qualification programs for implementation into the BFVS. A test evaluation master plan (TEMP) was prepared by the materiel developer in the Packaging Division. The TEMP would be used as a test document throughout the qualification program. A test integrated working group (TIWG) chaired by ARDEC was formed to review the TEMP and monitor the test program. TIWG consisted of major evaluators such as TECOM, AMSAA, Infantry School, CCAC, PM-AMMOLOG, and Operation Evaluation Command (OEC).

Additionally, a safety assessment report and a life cycle environmental assessment report were prepared by ARDEC and submitted to TECOM prior to the start of the test program. The safety procedures for handling the 25 mm in the metal container were provided for the test personnel. As determined in the environmental assessment, the container and the plastic component would pose no threat to the environment in the test sites.

The TEMP consisted of production qualification test series at TECOM's facilities, Combat Systems Test Activity (CSTA) for the rough handling tests and Yuma Proving Ground (YPG) for the air delivery tests; hazard classification test series at National Space Technology Laboratory (NSTL); and transportation test series at Defense Ammunition Center and School (DACS).

In addition to the above tests, the stowage interface test was conducted with TACOM as a parallel effort to the program.

#### **Production Qualification Test (PQT) at CSTA**

The PQT conducted at CSTA was the major test series for testing the integrity of the container. The series consisted of a rough handling sequence (leakage, secured cargo vibration, 3-foot drops, loose cargo, and 7-foot drops), firing tests, stacking test, salt fog test, temperature/humidity test, and chemical compatibility test. In addition, the human factors engineering evaluation was also conducted by BFVS soldiers at Aberdeen Proving Ground.

The PA125 containers, internal support components and live 25 mm ammunition were shipped to CSTA prior to the start of the test program. The ammunition tested were M791 APDS-T, M792 HEI-T, M793 TP-T, M794 dummy, M910 TPDS-T and M919 APFSDS-T cartridges. The M790 series of cartridges were obtained from the existing ammunition inventory. The two new cartridges, M910 and M919 were shipped from Aerojet. Also, the depleted uranium (DU) penetrator for the

M919 was replaced with tungsten because CSTA was not yet capable of handling DU cartridges at the test range.

Prior to the start of the program, a program review requested by PM-Bradley was conducted at APG. During the meeting, PM-Bradley was not satisfied with the PA125 configuration due to the use of the plastic internal system. Based on their bad experience of the M621 in the recent live fire test with the vehicle in which burning M621 generated toxicity and flammability problems. Both PM-Ammolog and the Packaging Division explained that the PA125 would significantly reduce the above problems because the plastic materials used were internal. If the plastic dunnage was on fire, the propellant in the cartridges would be set off and dominate the gas evolution. Initially, PM-Bradley insisted the dunnage be replaced with an all-metal design for the PQT. The all-metal dunnage would solve the above problems but would not protect the cartridges during rough handling as explained by the Packaging Division and PM-AMMOLOG. Nevertheless, at the conclusion of the meeting, PM-Bradley directed TECOM to replace the top and bottom restraining plates with a metal design in order to reduce the total plastic content.

Subsequently, CCAC was provided with funding and Aerojet was tasked to design and fabricate the top and bottom restraining plates with stock aluminum for the PQT at both CSTA and YPG. The TEMP was then modified to reflect this change. After the receipt of all the hardware including the aluminum restraining plates from Aerojet, CSTA started the test series in May 1991.

After the secured cargo vibration and 3-foot drop tests, the aluminum plates were found to cause abrasion and delinking problems. The plates fabricated by Aerojet were thinned down compared with the plastic design. This was done in order to save weight but also allowed plate movement inside the container. In addition to the above delinking and abrasion problems, some containers also failed the leak test because of the movement of the metal plates. Immediately, the Packaging Division requested the tests conducted thus far be repeated using the original plastic restraining design. It was stressed that the plastic design was chosen not only to provide a tight pack but also would act as a sacrificial packaging to absorb impact energy during rough handling for the protection of the cartridges. The retest program was successfully conducted without any of the above problems. TECOM then directed that the remainder of the test program be conducted with the plastic restraining plates. CSTA conducted the remainder of the tests successfully in April 1992. The test results were summarized as follows:

1. Leak Test

The PA125 container performed well in this area. The container passed the 3 psi seal repeatedly throughout the test sequence. The cover design was superior in the leakage performance compared to the M621 cover design which can only hold a 1 psi seal.

## 2. Secured and Loose Cargo Tests

Both tests were conducted in accordance with MIL-STD-810E which simulates the shock and vibration encountered in transportation when secured and when unconstrained. The container sustained minor external damage but the plastic internal support protected the two belts of linked cartridges adequately. No major problems were encountered in these two tests.

## 3. 0.9-Meter (3-Foot) Drop Tests

The 3-foot drop tests simulated the accidental drops that could happen during handling by personnel. As discussed before, the metal restraining plates caused delinking and leakage problems due to insufficient thickness. The delinking was very significant in the top and bottom drop orientations. The plastic system which provided a tight pack alleviated the problems.

## 4. 2.1-Meter (7-Foot) Drop Tests

The protective caps of the M791 and M910 cartridges were found damaged at both hot and cold temperature drops. This was attributed to the poor nose cap design and not to the lack of protection offered by the container. Protective caps were fabricated by a subcontractor to Aerojet. The caps may be fabricated with too much reground material and/or other processing problems during the injection molding operation. As a result, the caps have always been easily cracked or damaged during handling. Other than the cap problem, no other problems were noted.

## 5. 12.2-Meter (40-Foot) Drop Tests

The containers passed this safety drop successfully. No fire, smoke or explosion occurred after the drop tests and the damaged containers and the ammunition were able to be removed safely from the drop site.

## 6. Temperature and Humidity Test

The container, due to its excellent sealing capability, had no problem protecting the ammunition under such an environment.

## 7. Human Factors Engineering Evaluation

In addition to the evaluation by the CSTA test engineers, BFVS soldiers at the test site were able to evaluate the operational performance of the PA125 container with the vehicles available at APG. In general, the container was well received by the user but several constructive comments were provided for further improvement. As indicated by the user, the lifting handle was difficult to use when wearing gloves or mittens. Lifting on top of the vehicle was difficult because of the



weight (55 lbs) and a side handle was needed to lift the container out of the floorboard stowage compartment of the vehicle. As a result of these comments, a side spring-loaded handle was added to the technical data package of the PA125 container as shown in appendix B.

#### **8. Firing Test**

The baseline tests were conducted with the 25 mm ammunition prior to the start of the PQT. Rounds were extracted throughout the rough handling sequential testing for the firing tests. All ammunition tested showed no degradation in dispersion, fuze arming (for M792) and metal-parts security performance when compared to the baseline data.

In conclusion, the PQT series conducted at CSTA was a major success. The PA125 container demonstrated excellent protection for the 25 mm ammunition with the all plastic internal support system. The container displayed minor logistic problems in human factor engineering evaluation and CSTA recommended a modification of handle designs be implemented in the production of the container. The details of the test results can be found in the CSTA Report No. CSTA-7281, titled Final Report, Production Qualification Test (PQT) of 25 mm Ammunition Container, PA125, for the Bradley Fighting Vehicle System (BFVS), by Gregory Brewer, dated May 1992.

#### **PQT - Air Delivery Test at Yuma Proving Ground**

##### **Test Objective**

The test objective was to acquire data to determine if the PA125 container packed with tactical rounds, M792 and M919 can be air dropped without affecting the functional performance of the ammunition.

##### **Tests Conducted and Results**

The tests were conducted in accordance with the test plan developed by YPG. The containers and the ammunition were provided by ARDEC and the rigging procedures were developed by U.S. Army Natick Research Development and Engineering Center (NRDEC). YPG was responsible for providing the airplanes for the air delivery tests and conduction of the actual test. In addition, the containers were also leak tested before being used for air delivery testing. The ammunition, after the air drops, were tested for firing performance.

The types of air drops performed are listed as follows. Only the two tactical rounds were tested for air delivery. At the time, M791 was scheduled to be replaced by the M919 APFSDS-T cartridge which was still under development. However, at the conclusion of the PA125 container program, the M919 cartridge was not fielded because of the gun erosion problems. NRDEC and ARDEC are currently reviewing the data generated by the M919 to determine if analogy can be applied to

the M791 cartridge. The M919 cartridges tested were also manufactured with tungsten penetrators instead of the standard depleted uranium penetrators.

**Air Delivery Test Performed:**

- a. A-7A cargo sling, low velocity
- b. A-7A cargo sling, high velocity
- c. A-22 cargo bag, low velocity
- d. A-22 cargo bag, high velocity
- e. A-7A cargo sling, malfunction
- f. Low altitude parachute extraction (LAPE) in pallet configuration
- g. Pallet drop, low velocity
- h. Firing performance

All containers, after passing the 3 psi leakage test, were subjected to the above air drop tests using the C-130 aircraft from the US Air Force. All drops were successfully completed without any problems (app C). The rigging designs had successfully protected the container and the ammunition. The damage sustained by the containers was limited to minor dents and scuff marks and the packaged ammunition was able to be extracted without difficulties. Subsequently, selected ammunition was used for fuze arming (M792 only), dispersion and metal part security firing tests with the results being very satisfactory.

**Conclusion**

The above successful program will provide the qualification for the PA125 when packed with tactical ammunition for air delivery which was not done for the M621 container. This additional benefit provided by the PA125 would greatly enhance the operation of the Bradley fighting vehicle system.

**Hazard Classification Test at NSTL**

**1. Objective of the Test**

The objective of the hazard classification test was to establish data to be used in determining hazard classification for 25 mm ammunition shipped and stored in the new metal PA125 container.

**2. Test Procedures**

The tests were conducted as stated in the TEMP, in accordance with U.S. Army Technical Bulletin (TB) 700-2, DoD Explosive Hazard Classification Procedures, dated December 1989. Classification was based on the reaction of ammunition and explosives to specified initiating influences. Based on the reactions obtained, this procedure provided for assignment of appropriate hazard classifications. The tests included single package test, stack test and external fire stack test for both Honeywell

and Aerojet M792 HEI-T cartridges in PA125 container and Aerojet M910 and M919 (with tungsten penetrator) in PA125 container.

**Single Package Test** - A single cartridge was prepared to act as the donor cartridge by affixing an M70 electric detonator to the primer of the cartridge. This cartridge was then placed in the centermost position in the container.

**Stack Test** - A cartridge was prepared to act as the donor cartridge in the test by placing approximately one gram of igniter mix and an electric match in the primer tube of the cartridge. This cartridge was then placed in the centermost position in the top clip of the donor PA125 container of cartridges. A small hole was drilled in the lid to allow room for the lead wires of the electric match. The stack tests were set up by surrounding one donor PA125 container of cartridges with four more acceptor containers of cartridges. The acceptor containers were placed above, below, and on two sides of the donor containers. Finally, sand-filled bags were used to surround the boxes to provide confinement.

**External Fire Stack Test** - In this test, five PA125 containers packed with 25 mm cartridges were positioned on a steel crib one meter high. Kindling was piled in the crib beneath the containers and drenched with diesel fuel. The kindling was ignited using two 20 gram black powder squibs and two electric matches.

### 3. Test Results

**Single Package Test** - Only M910 cartridge was performed for this test. The result indicated that there was no mass detonation occurred. The reaction was limited to the donor cartridge causing a slight bulge to the container.

**Stack Test** - All four cartridges tested experienced no mass detonation of the contents. The bulging effect was more severe for the M792 cartridges.

**External Stack Test** - All cartridges tested also experienced no mass detonation of the contents. The cartridges reacted singularly or in small groups during the fire tests. The majority of the fragments were found within 50 feet of the crib. The farthest fragments found for M910, M919 and M792 were 340 feet, 290 feet and 480 feet, respectively.

### 4. Conclusion

Based on the test conducted above, the final hazard classification request for the M910 cartridge packed in the new PA125 container has been submitted to the Field Safety Activity, Charlestown, Indiana through the System Safety Office, ARDEC. The recommendation of the hazard classification is as follows:

DOD hazard class: (04) 1.2 C  
DOD storage compatibility group: C  
DOT hazard class: 1.2 C  
DOT container marking: cartridges for weapons, inert projectile  
DOT label: explosive 1.2 C  
UN serial number: 0328  
Net explosive weight: 0.0 kg (0.0 lb)  
Net propellant/pyrotechnic weight: 0.10173 kg (0.2243 lb)  
Explosive weight f/QD determination 0.10173 kg (0.2243 lb)

The request for M792 cartridges with PA125 container is being processed at the present time. The final hazard classification for the M919 was on hold until the gun erosion problems are resolved. Because of this change, the decision of continuing the production of M791 cartridges has been made. As a result, the final hazard classification for M791/PA125 will have to be assigned either by analogy or conducting the above hazard classification test series.

The details of the above tests are provided in the reports prepared by the hazard range at Stennis Space Center, new name for NSTL.

## **Transportation Test**

### **Objective of the Test**

The objective of the test was to determine the effectiveness of pallet configuration for transportation by rail and truck.

### **Test Procedures and Results**

The test program was conducted in accordance with MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. The pallet design consisted of a standard metal base (40" X 44") and a metal base adapter, an intermediate pallet adapter and a metal top lift. The pallet housed a total of 42 PA125 containers in a matrix of 3X7, two tiers. The total weight of the pallet was 2,450 lbs. approximately. The tests conducted were outlined as follows:

1. Superimposed Load Test - To simulate the stacking height of 16 feet, the single unit load was loaded to 22,600 lbs compression for a period of one hour. At the end of one hour, no noticeable deformation of the pallet was noted.

2. Repetitive Shock Test - Similar to the loose cargo test, the pallet was subjected to a 1 inch amplitude starting at a frequency of 3 Hz and the frequency was steadily increased until a 1/16-inch-thick feeler gage may be momentarily slid between the platform and the base of the pallet. The test duration was 90 minutes for

each of the longitudinal and lateral positions. The pallet sustained no noticeable damage.

3. Edgewise Rotational Drop Test - Each side of the pallet base was placed on a beam displacing 4 1/2 inches above the floor. The opposite side of the pallet was raised to a height of 24 inches and then dropped. No noticeable deformation was noted to the pallet or pallet assemblies during this test.

4. Incline-Impact Test - The inclined plane was set to allow the pallet to travel eight feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No deformation was observed.

5. Mechanical Handling Test - The sling test consisted of five different lifting configurations using the top pallet assembly and a four-legged sling. The sling configurations included a three corner, two alternate corners, two pair of adjacent corners and a single corner lift. No permanent deformation to the pallet was observed.

### **Conclusion**

The metal pallet configuration for the PA125 container passed the MIL-STD-1660 test successfully. The metal pallet will be more durable hence increase the reusability. Furthermore, the metal pallet will withstand chemical washing processes in the event the whole pallet has to be decontaminated. The current configuration consisting of 42 containers is also more efficient than the M621 configuration which consists of only 27 containers.

### **Stowage Interface**

In addition to the packaging requirements, the PA125 container must be compatible with the stowage system of the vehicle. Depending on the type of Bradley vehicle, approximately 30 containers of 25 mm ammunition are stowed with the vehicle. The containers are stowed on the racks on the sides, underneath the seats and the floorboard (app D).

The design of the PA125 followed the interface control drawing of the M621 container. During the stowage evaluation for the PA125, no problems were found except in the floorboard areas. Eight containers are stowed on the floorboard with two compartments of three containers and one compartment of two containers. In order to keep the containers in place during transportation, fin dividers are welded in each compartment to separate the containers in the A1 vehicle and block dividers are used for the A2 vehicle. It was found that these dividers were designed to take advantage of the indentation at the corner and the middle of the M621 container. The PA125 container without these features was found to have interference in the floorboard stowage.

This problem was brought to the attention of the vehicle designers at TACOM. Following an initial investigation with the vehicles at APG, TACOM then assigned this task to VSE, a contractor at Washington DC, to handle the interface studies.

VSE conducted a series of studies at FMC with a sample of 20 vehicles. At the conclusion of the studies, VSE recommended that all dividers except the one next to the torsion bar (for protection of the bar) be removed. The floor plate on top should provide sufficient security for the container when the vehicle is in motion. VSE also concluded that the available space at the worse case can only fit the containers about 98 percent of the time due to the tolerance stackup and the thick welding. Subsequently, TACOM released an engineering change proposal (ECP) to have the new floorboard changed for new production and also for retrofit of all existing vehicles.

## **IMPLEMENTATION**

### **Engineering Release Record (ERR)**

After the successful completion of the PQT at APG, TECOM issued a safety confirmation statement for the PA125 container which allowed the use of PA125 container for the packaging of 25 mm in the BFVS. With the approval from TECOM, ARDEC implemented the technical data package (TDP) into the M910 and M919 systems by releasing the ERR in December 1991. The ERR was approved by the Configuration Board at ARDEC and the TDP was available for procurement actions for any future buys of the above cartridges.

Concurrently, all the required national stock numbers (NSN's) for the PA125 container and the 25 mm ammunition were requested through Rock Island Arsenal. The maintenance manual to handle PA125 was also completed for operation in the field. The request for final hazard classification for M910 packed in PA125 was submitted to the Field Safety Activity, Charlestown, Indiana. As mentioned previously, to date the M919 cartridge is not ready for fielding until the gun erosion problems are resolved. Because of this, the packaging effort of PA125 with M919 cartridge is on hold.

### **ECP for M790 series**

After the successful release of the TDP into the M910 25 mm system at ARDEC, the next and final step was to implement the TDP into the M790 family of cartridges, M791, M792, M793 and M794 which are transitioned ammunition items controlled by Rock Island Arsenal. An ECP was prepared by the Packaging Division and submitted to Rock Island Arsenal for approval in March 1992. After review by the Configuration Control Board (CCB), ARDEC representatives were invited to attend a CCB level II meeting to discuss the above ECP. In May 1992, ARDEC attended the level II meeting and briefed the board members at Rock Island Arsenal on the entire PA125 program

and strongly recommended the implementation of the PA125 container because of the benefits.

As discussed in the meeting, the implementation of the container into production can be initiated with either the M910 or the M790 series buys. The important issue would be the tooling investment which was estimated at a half of a million dollars including both metal container tooling and plastic molds. Excluding the cost of the tooling, the unit cost for the PA125 container was estimated at \$25\* and the internal support system at \$15 for a total of \$40. Compared to the current unit cost of the M621 container at \$50, the above tooling cost for the PA125 container can be recovered in the first 50,000 containers procured based on the savings of \$10 per container. After this, the savings in the subsequent buys will be very significant. In addition, the PA125 will offer extreme ruggedness for protection, increased reusability and most important of all, elimination of the toxicity and flammability problems.

The ECP was approved at the conclusion of the meeting by all board members with one modification. In order to minimize the number of loose internal components inside the container for increased field operation efficiency, the board recommended the top and bottom foam filler pads be adhered to the cover and the bottom of the container. An ECP was immediately released at ARDEC to incorporate an adhesive for the above recommendation.

To date, the TDP for the PA125 is complete for all 25 mm ammunition. Both ammunition contractors, Aerojet and Alliant Tech (Honeywell) are provided with the both the TDP and container samples for initial evaluation. The current plan is to initiate the PA125 buys for M910 cartridges in FY93 followed by the M791 and M793 buys also in FY93/94 time frame. The container can be procured as contractor furnished material (CFM) along with the delivery of the 25 mm ammunition. However, the Government still maintains the control of the TDP of the container. As opposed to government furnished material (GFM) method, CFM reduces the tedious procurement procedures for obtaining the containers.

### **Future Work**

The future work of the program is to support the production start-up for the container and the internal support system. In addition, any comments and/or suggestions from the user community or engineering design people which can result in constructive change for the container will be considered.

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\* FY92 money

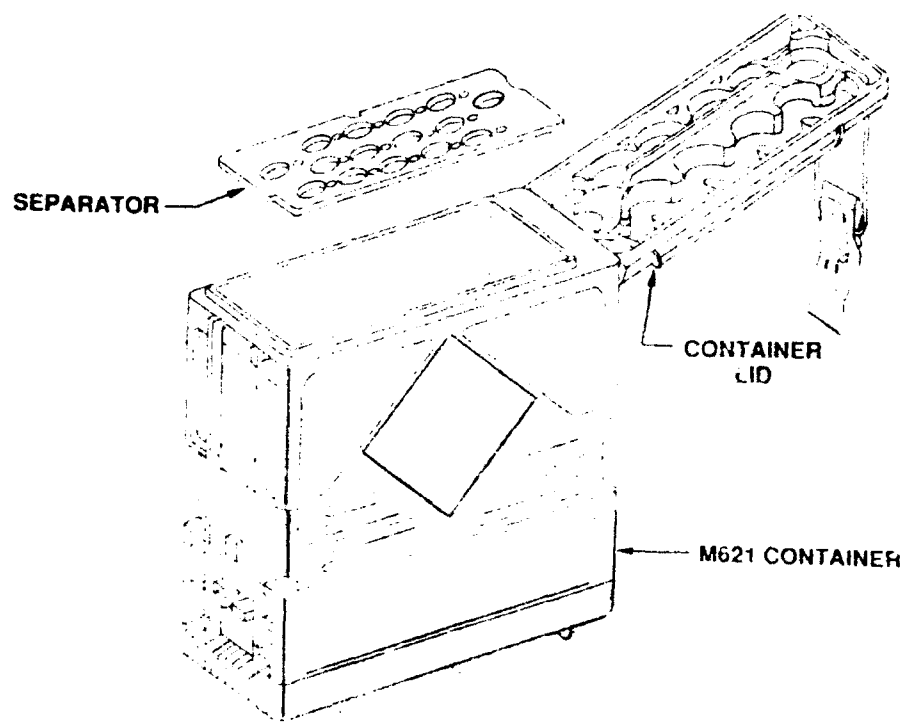


Figure 1. Plastic M621 container for 25 mm ammunition

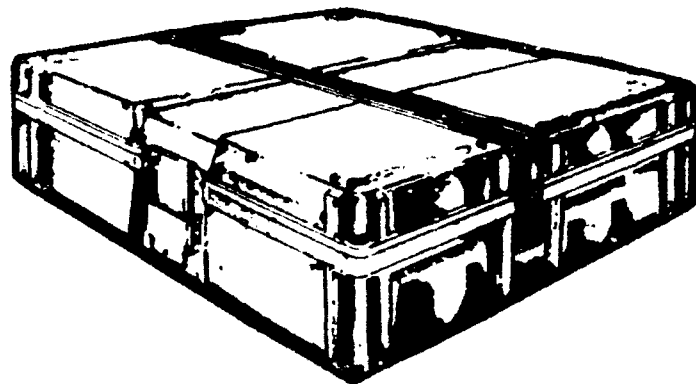
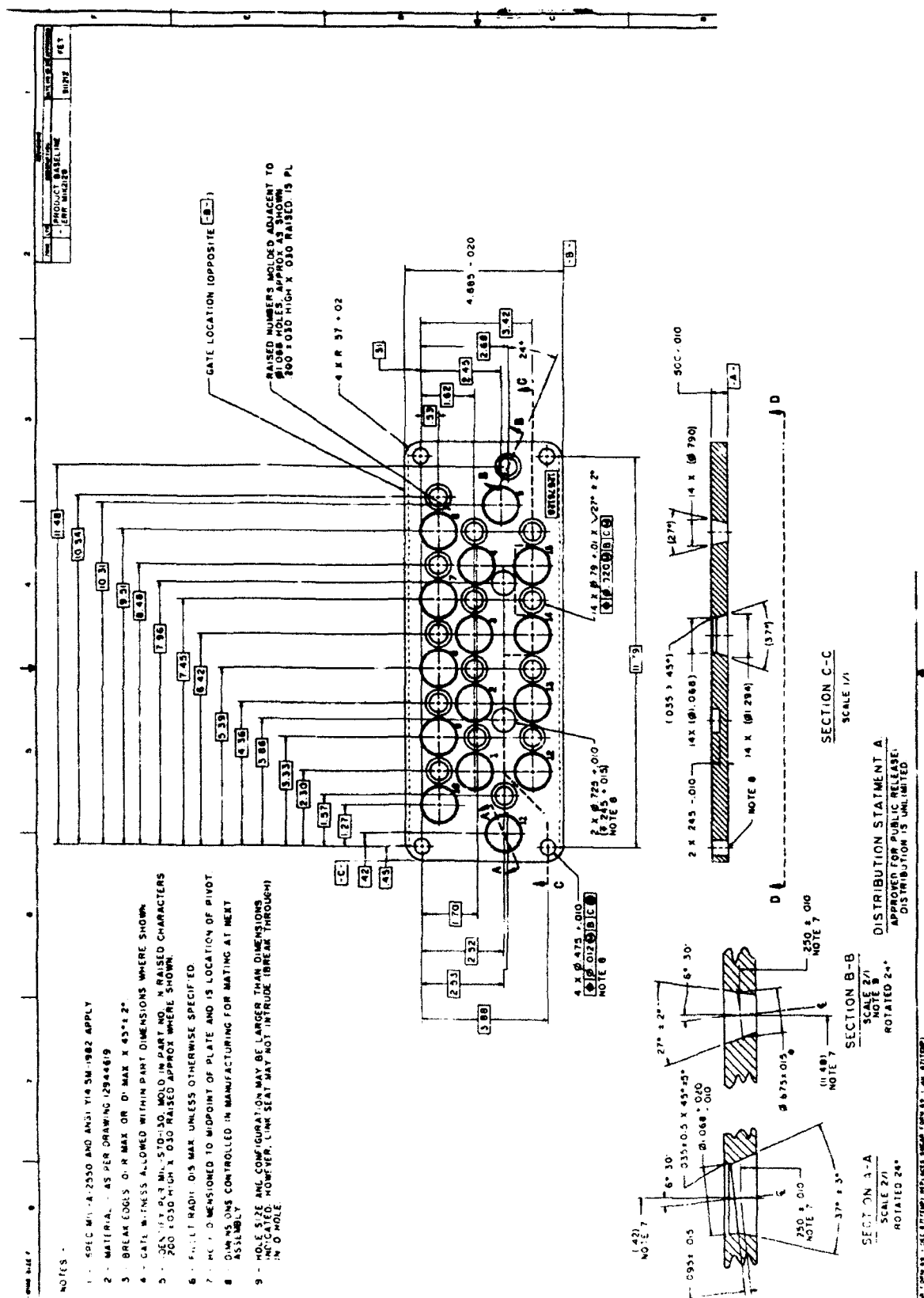


Figure 2. SMC container fabricated by ECS, Inc.





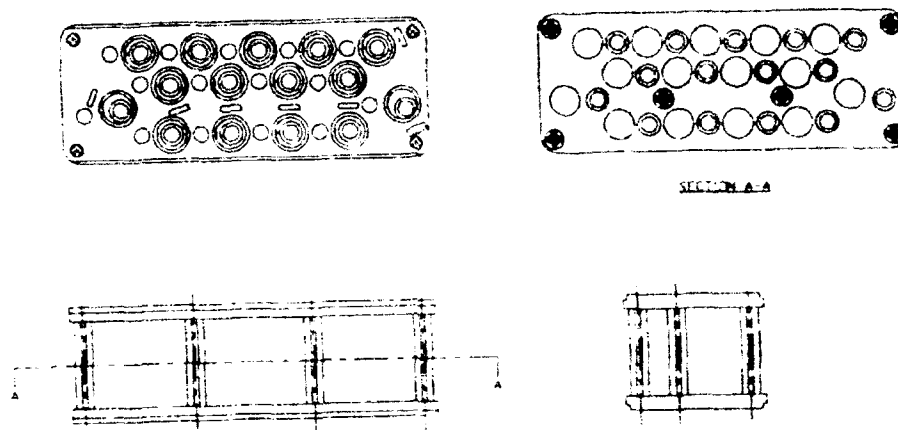


Figure 4. Improved internal support

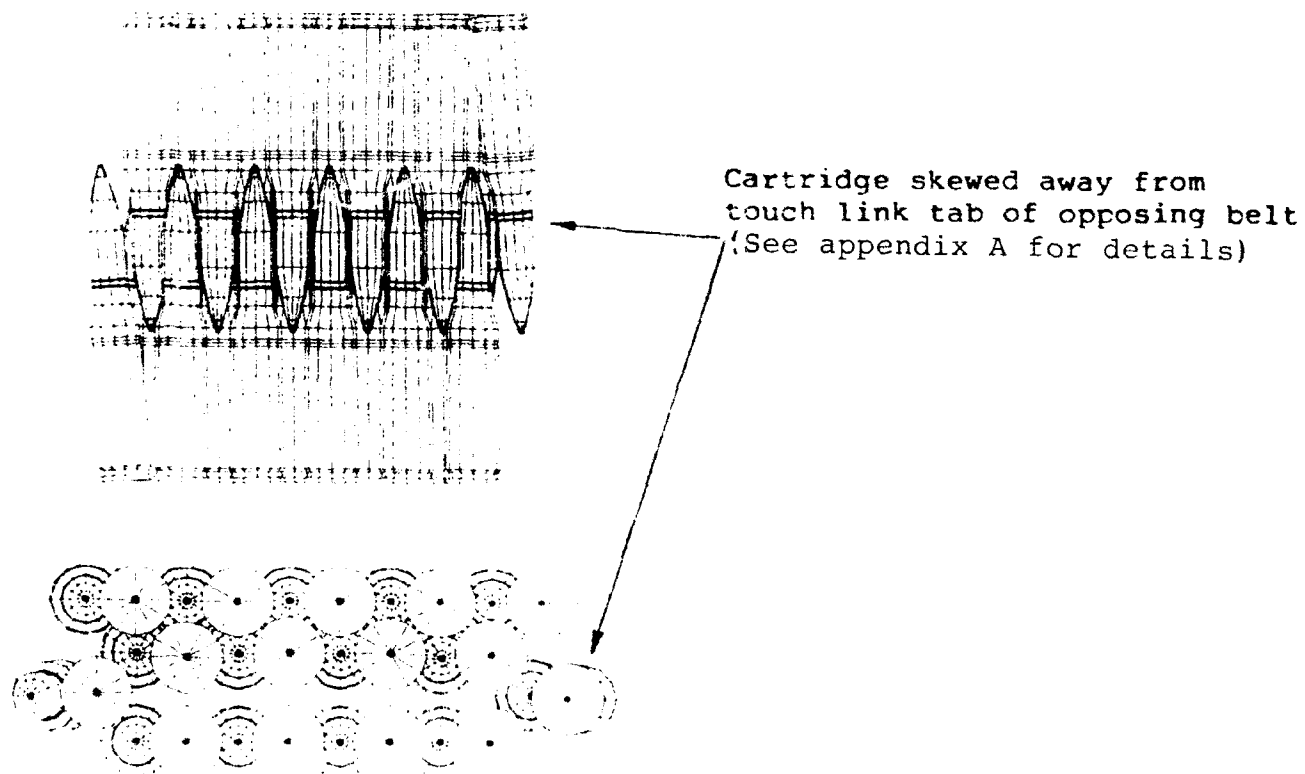


Figure 5. Design modification for the interference

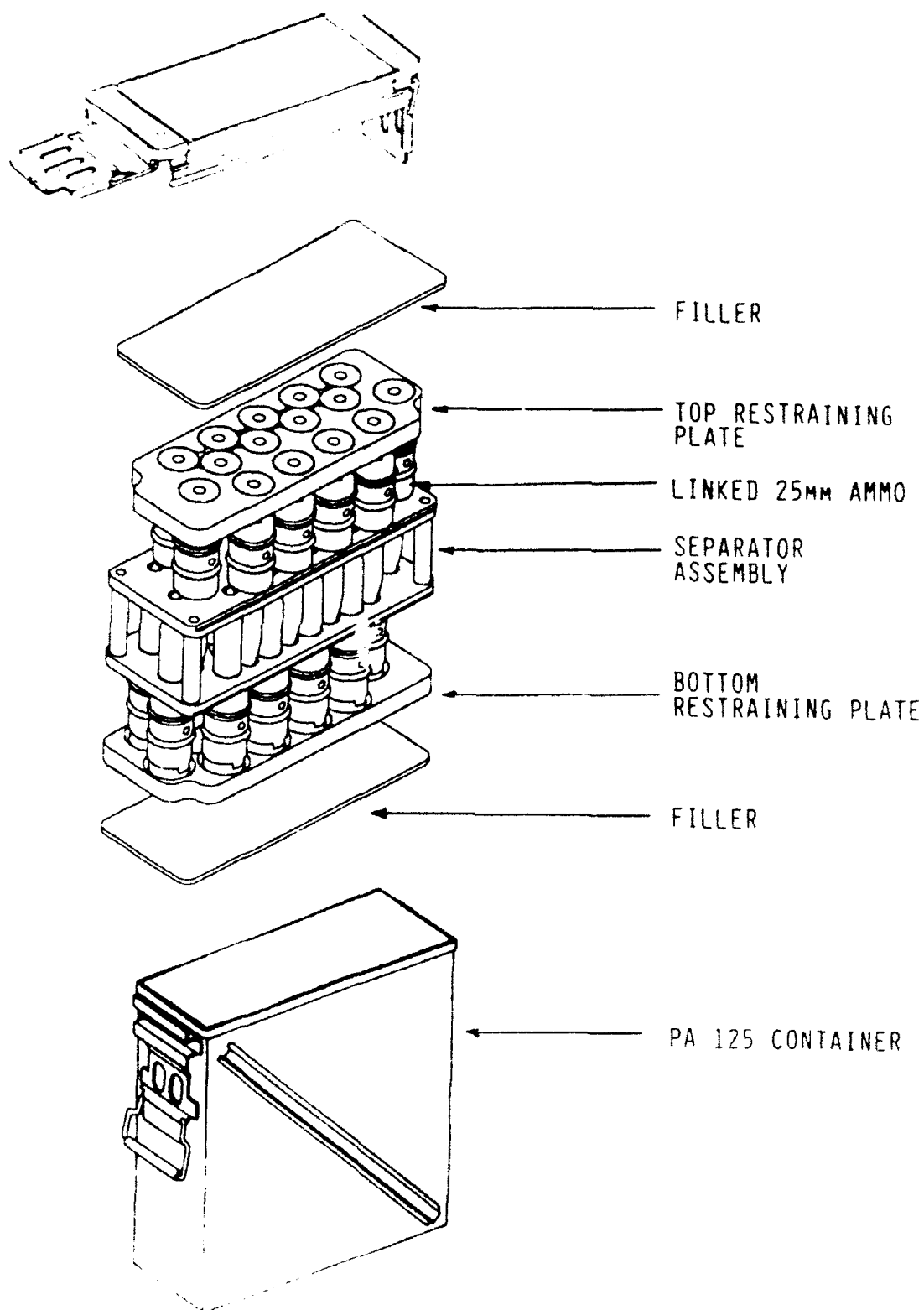


Figure 6. PA 125 25 mm ammunition container

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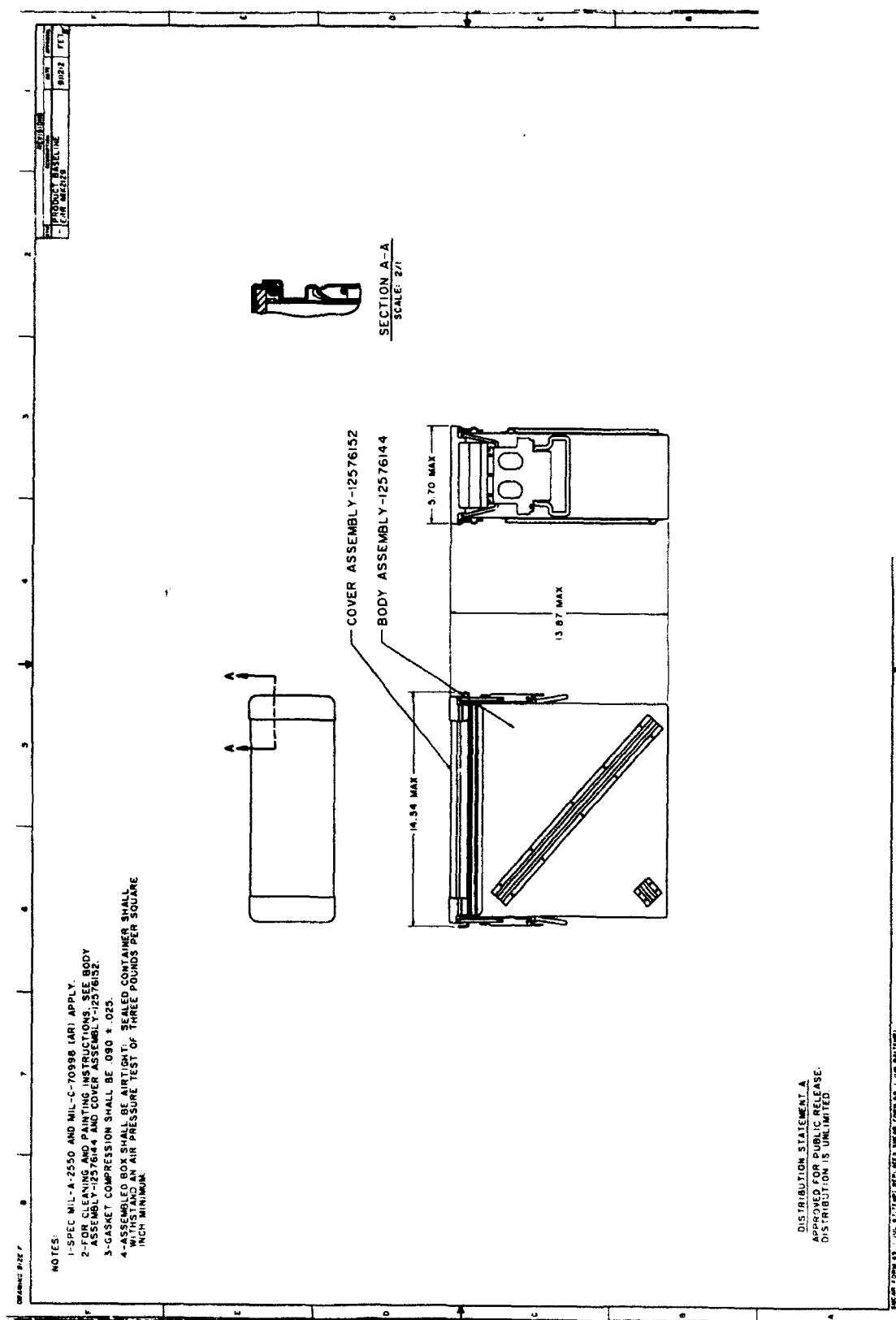
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## GLOSSARY

AMSAA	Army Materiel Systems Analysis Activity
APG	Aberdeen Proving Ground
ARDEC	Army Research Development and Engineering Center
BFVS	Bradley fighting vehicle system
CCAC	Close Combat Armament Center
CCB	Configuration Control Board
CFM	Contractor furnished material
CSTA	Combat Systems Test Activity
DACS	Defense Ammunition Center and School
DU	Depleted uranium
ECP	Engineering change proposal
ERR	Engineering release record
GFM	Government furnished material
HSLA	High strength low alloy steel
LAPE	Low altitude parachute extraction
MC	Materiel change
NSN	National stock number
NIPHLE	National Institute of Packaging Handling and Logistic Engineers
OEC	Operation Evaluation Command
PSI	Pounds per square inch
PIP	Product Improvement proposal
PM-AMMOLOG	Project Management-Ammunition Logistics
PTI	Polymer Technology Inc.
PQT	Product qualification test
TACOM	Tank Armament Command
TECOM	Test and Evaluation Command
TEMP	Test evaluation master plan
TB	Technical bulletin
TDP	Technical data package
TIWG	Test integrated working group
SMC	Sheet molding compound
YPG	Yuma Proving Ground

**APPENDIX A**

**DRAWINGS OF THE PA 125 CONTAINER  
AND INTERNAL SUPPORT**



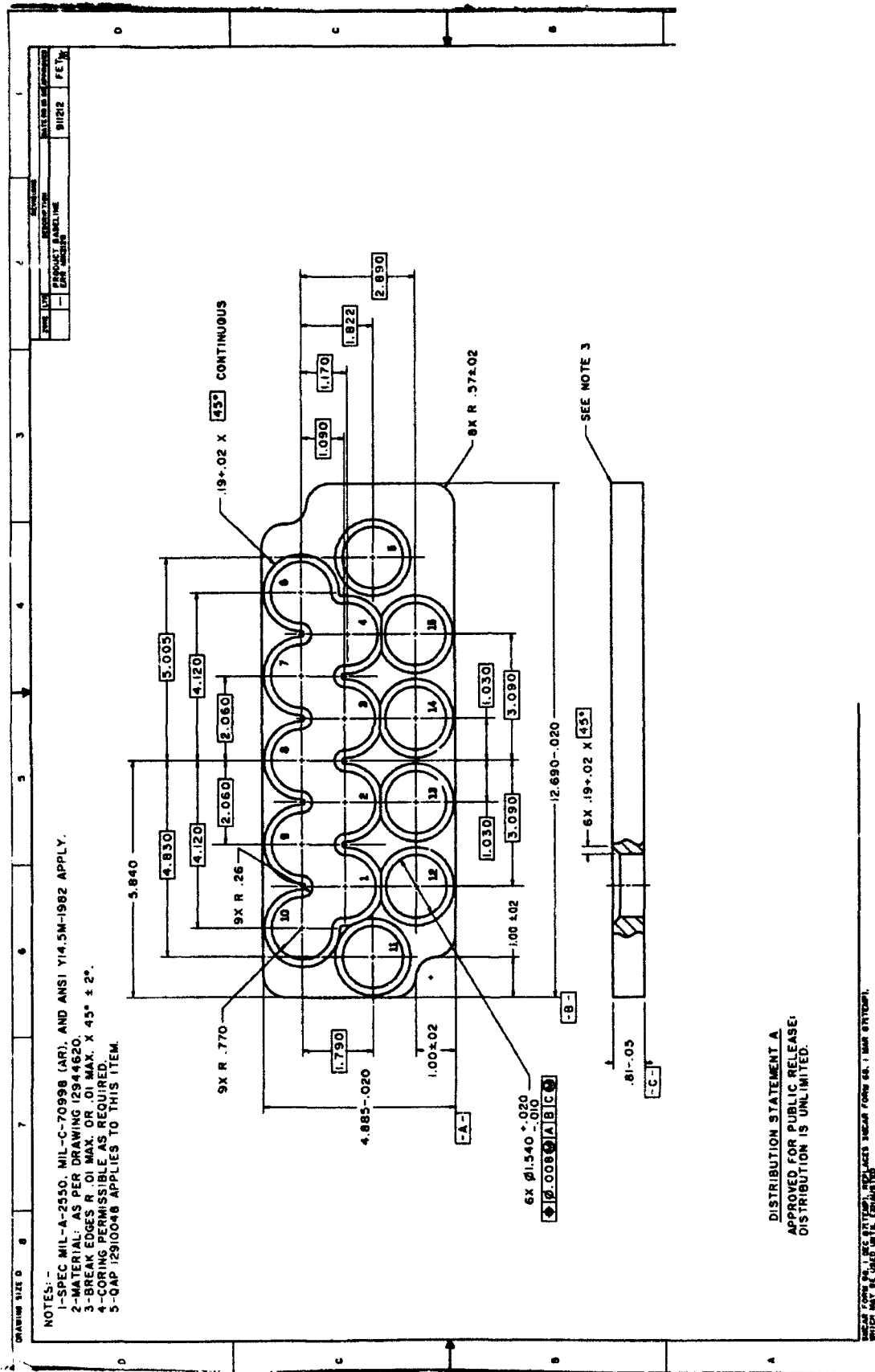


Figure A-2. Plate, restraining



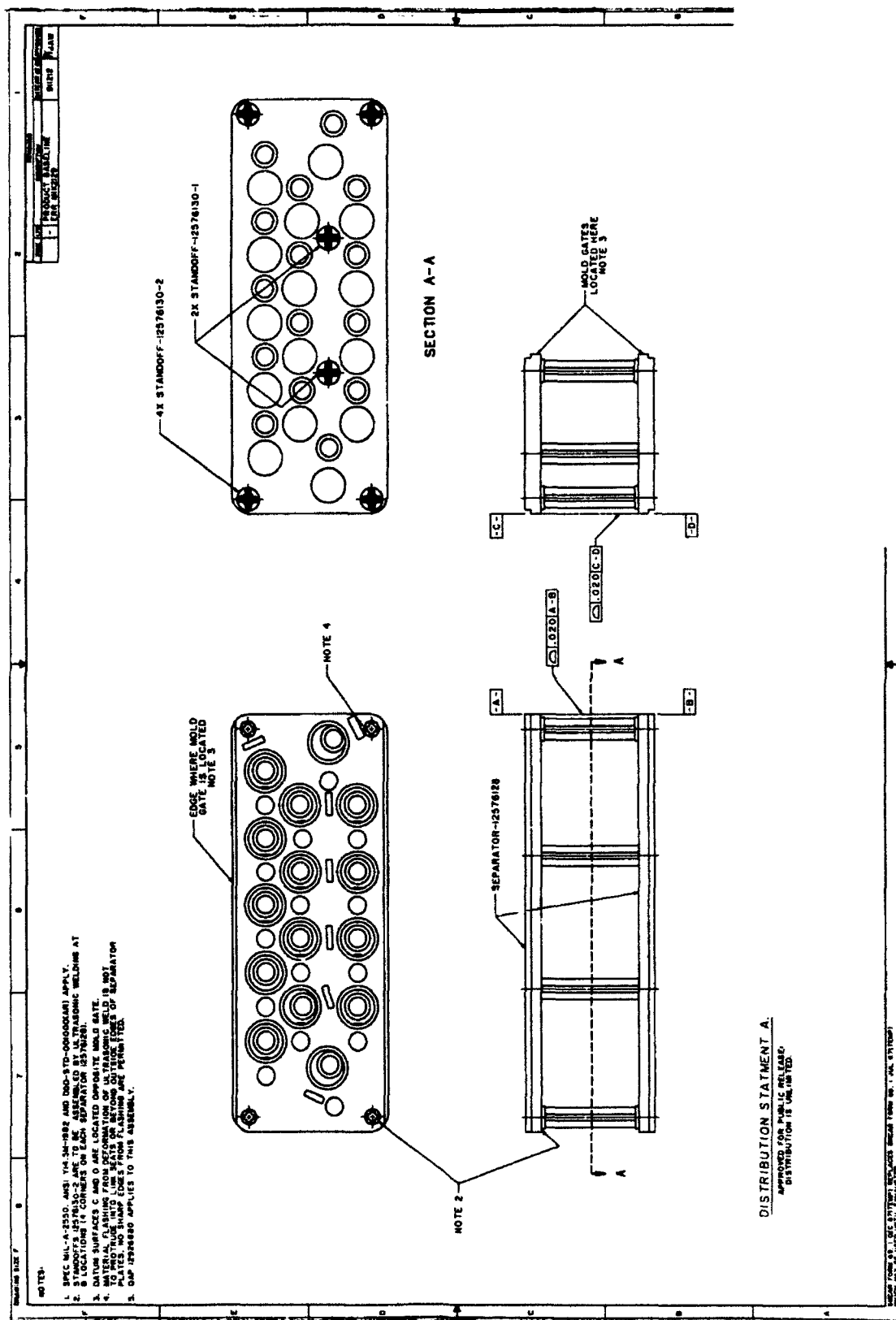


Figure A-3. Separator assembly

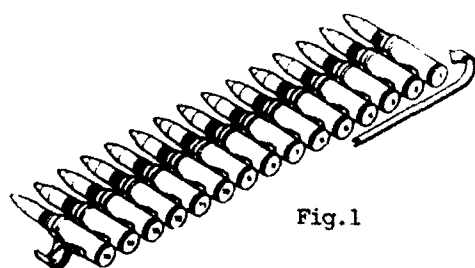


Fig. 1

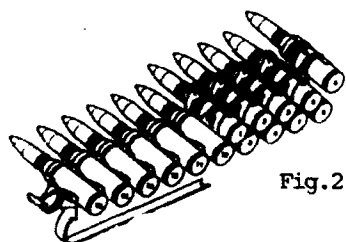


Fig. 2

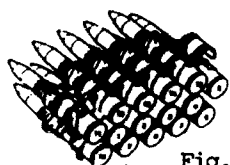


Fig. 3



Fig. 4

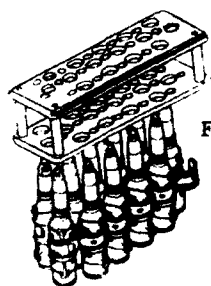


Fig. 5

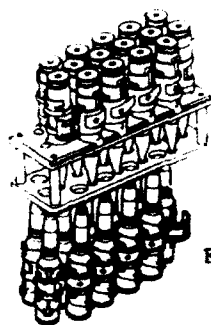


Fig. 6

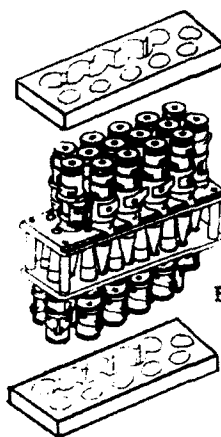


Fig. 7

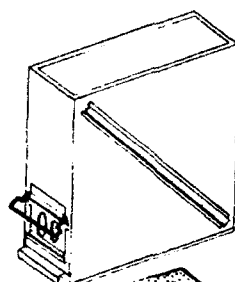


Fig. 8

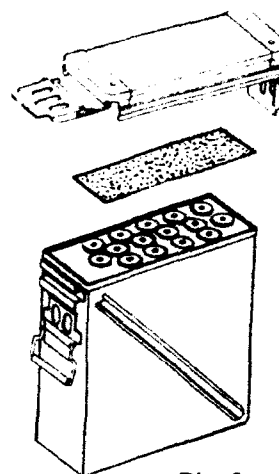


Fig. 9

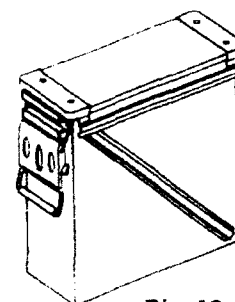
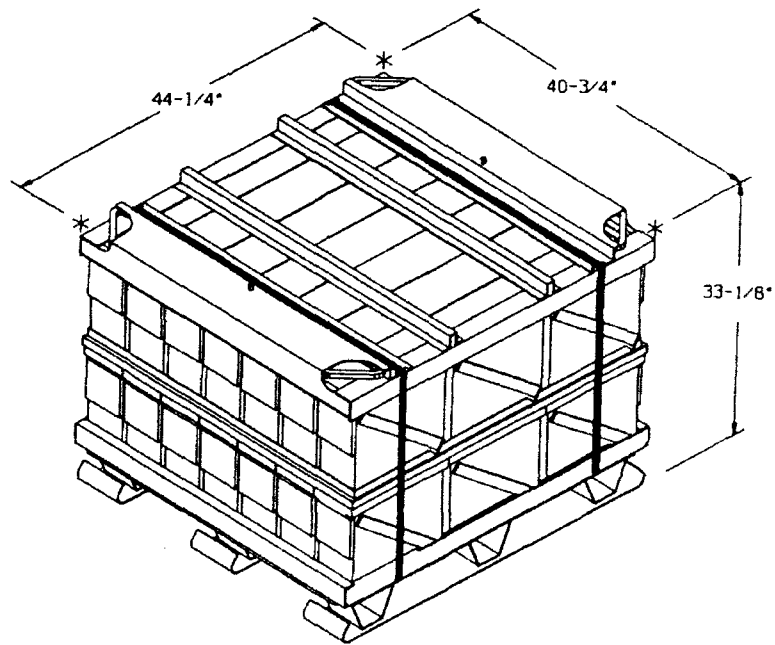


Fig. 10

Figure A-4. Packing diagram, PA 125 container, 25 mm ammunition



PALLET UNIT

BOX	- - - - -	42 EACH	• 54 LBS (APPROX)
CUBE	- - - - -	34.57 CUBIC FEET (APPROX)	
GROSS WEIGHT	- - - - -	2.475 LBS (APPROX)	

Figure A-5. Pallet unit

**APPENDIX B**

**PICTURES OF THE PA 125 CONTAINER  
AND INTERNAL SUPPORT**

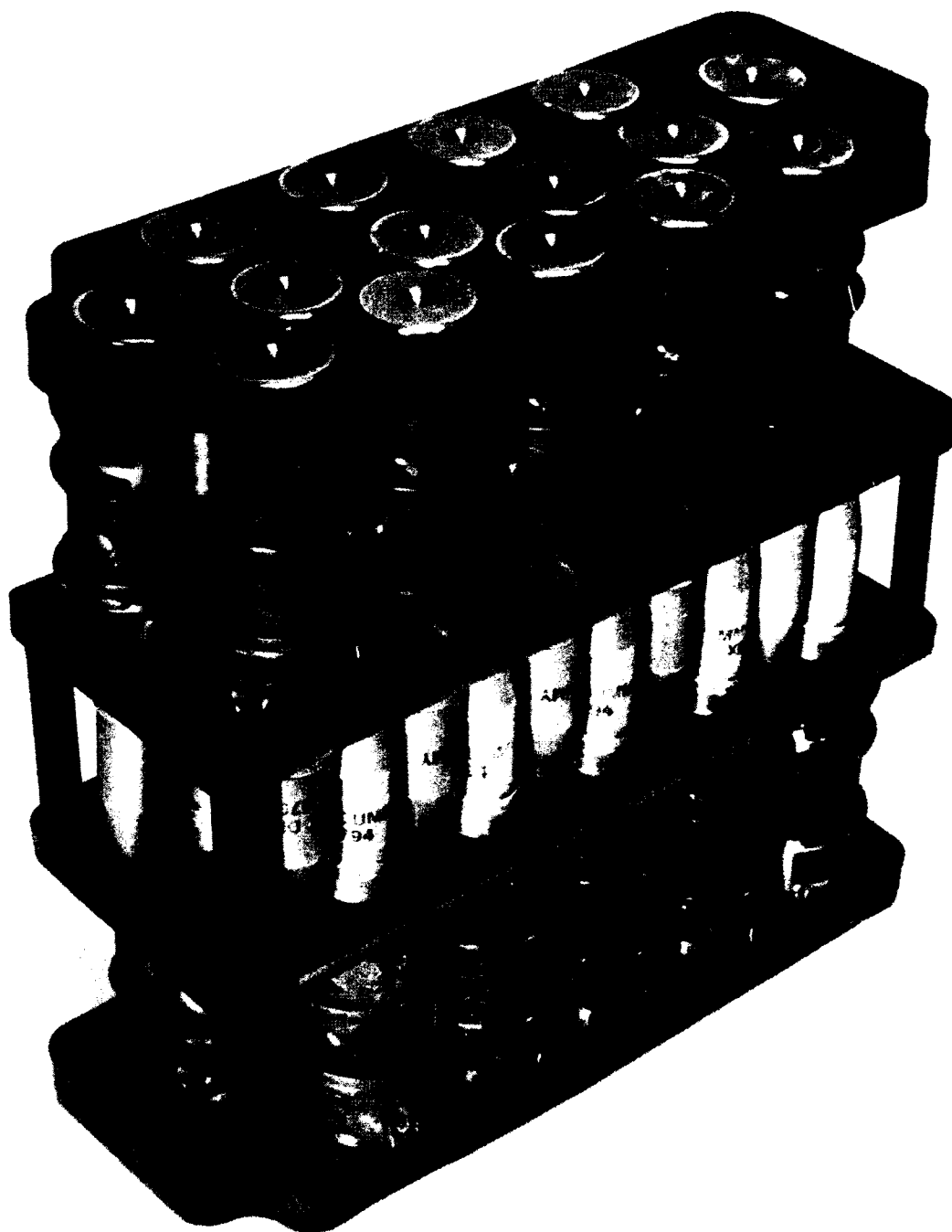


Figure B-1. Injection molded plastic internal support system

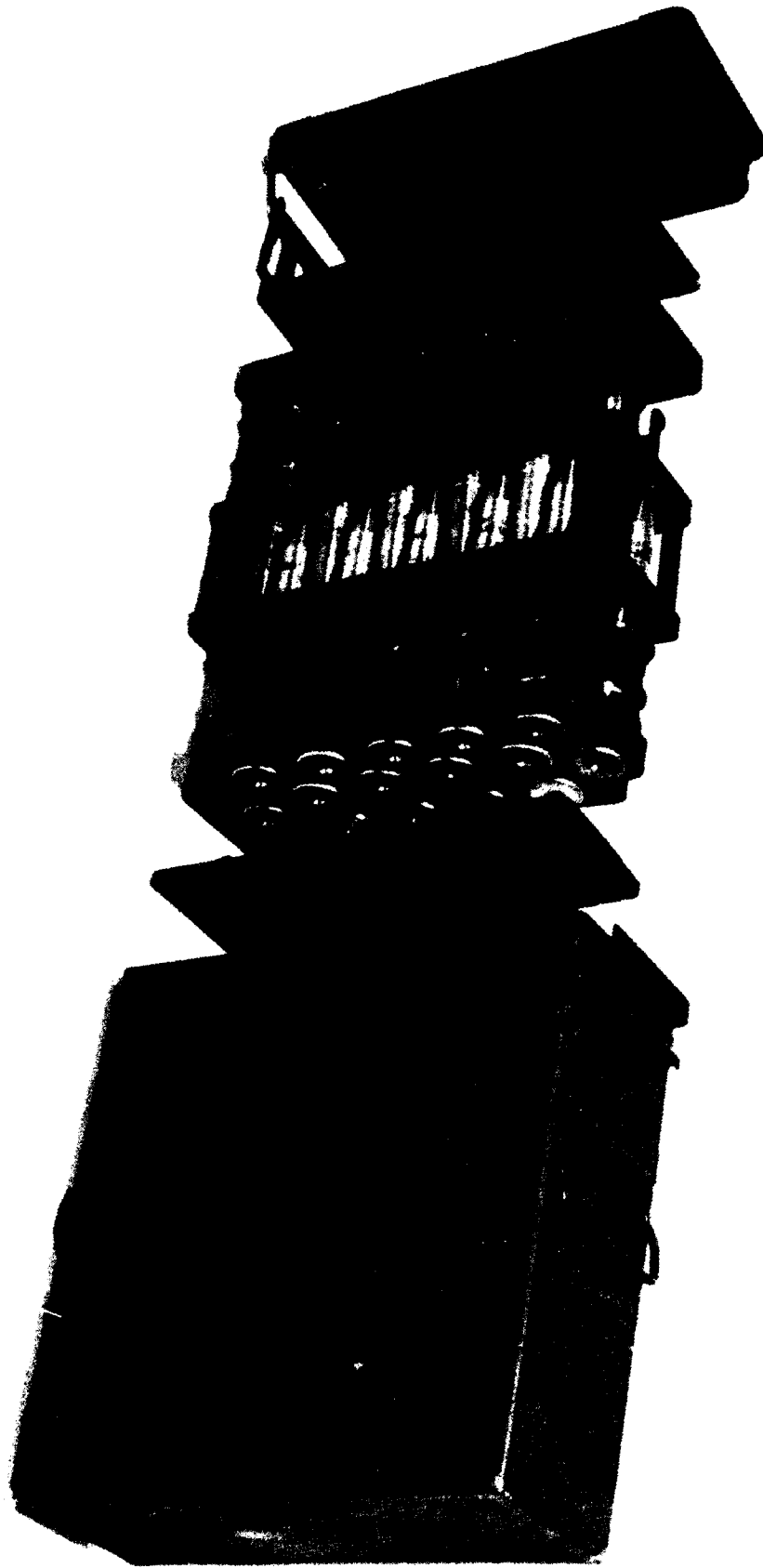


Figure B-2. PA 125 metal container for 25 mm ammunition



Figure B-3. Metal container with spring loaded side handle

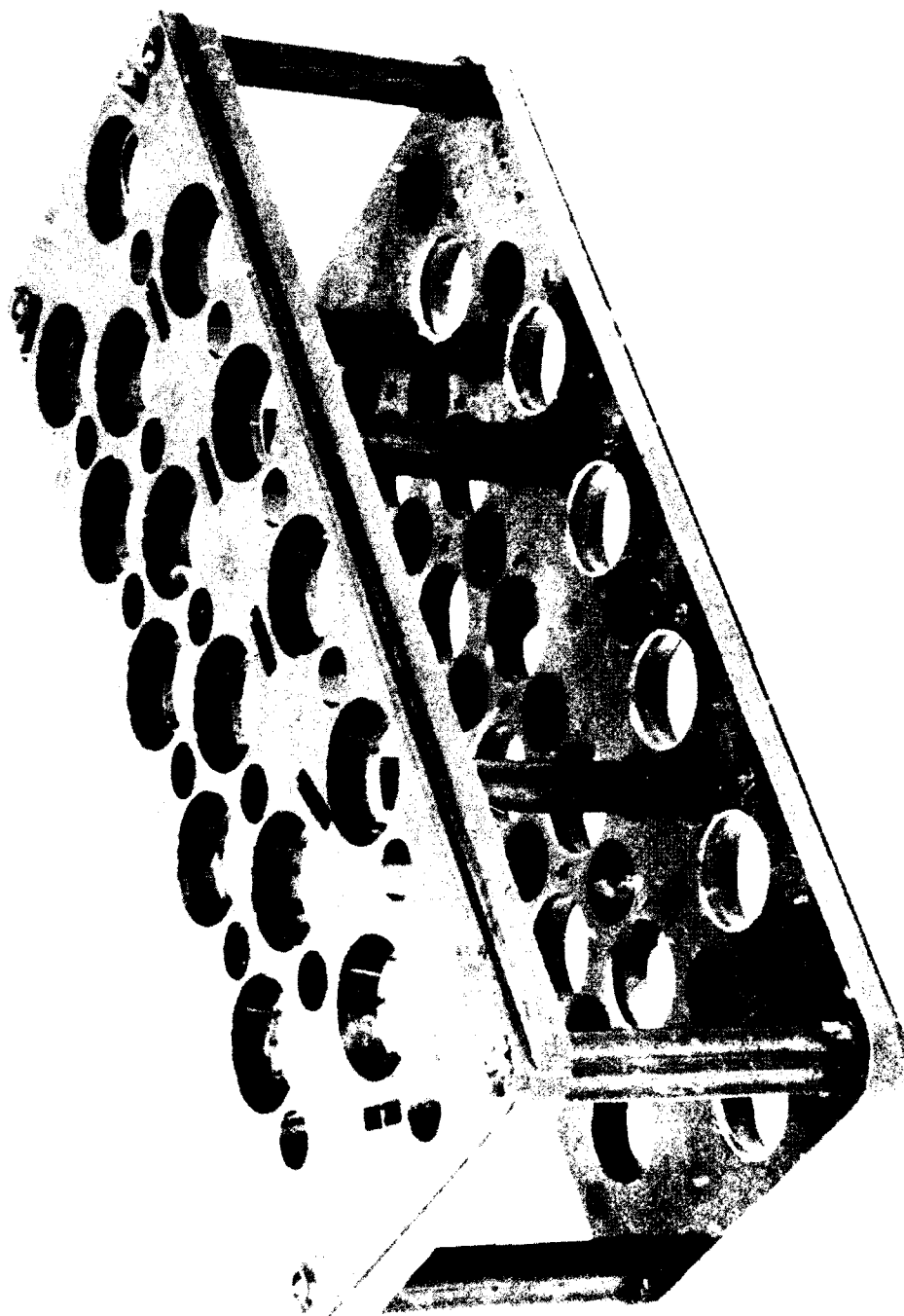


Figure B-4. Nylon (Zytel) center support with ultra sonic welded posts



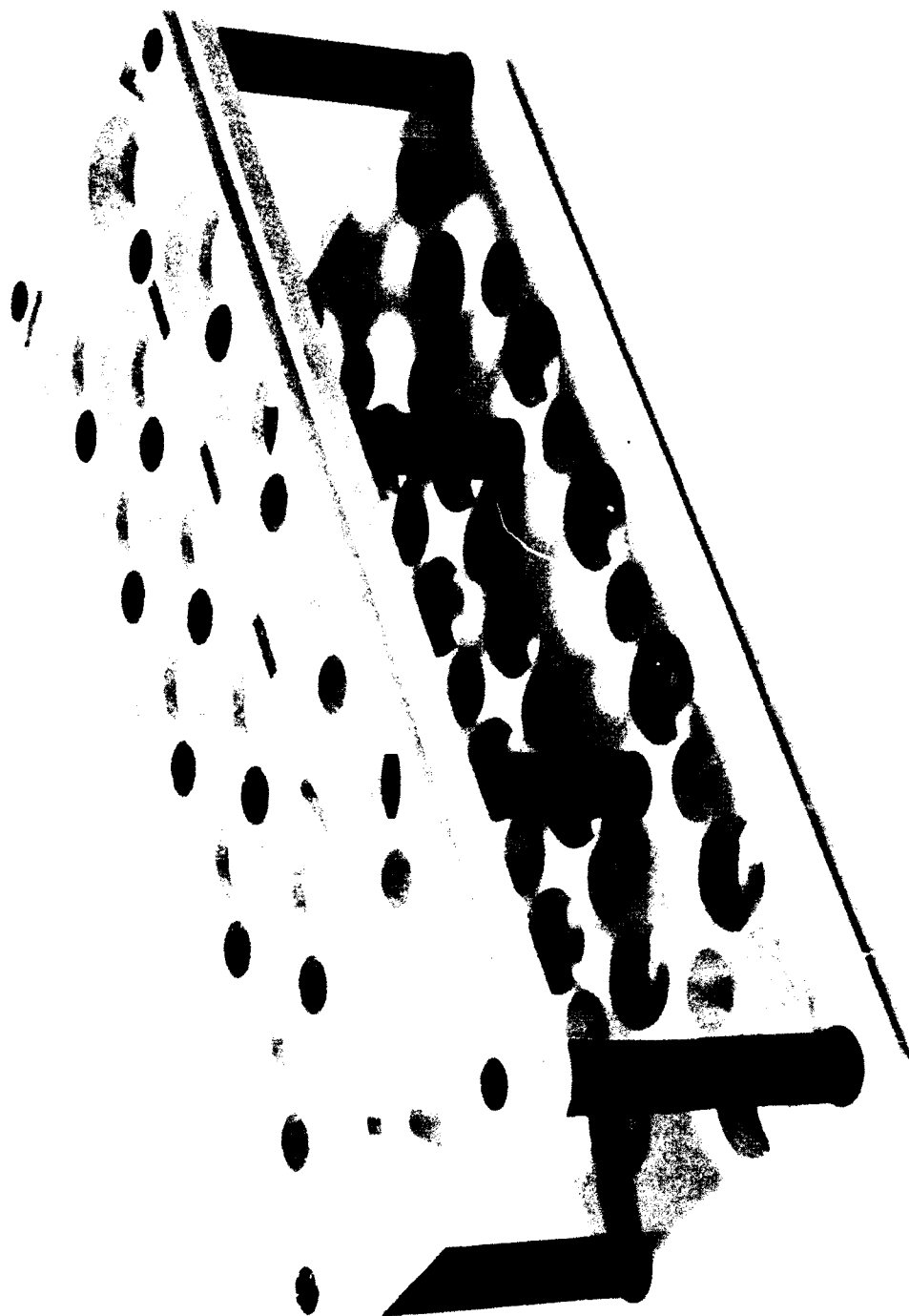


Figure B-5. Compression molded SMC center support with glued posts

**APPENDIX C**  
**PICTURES FROM AIR DELIVERY TESTING**

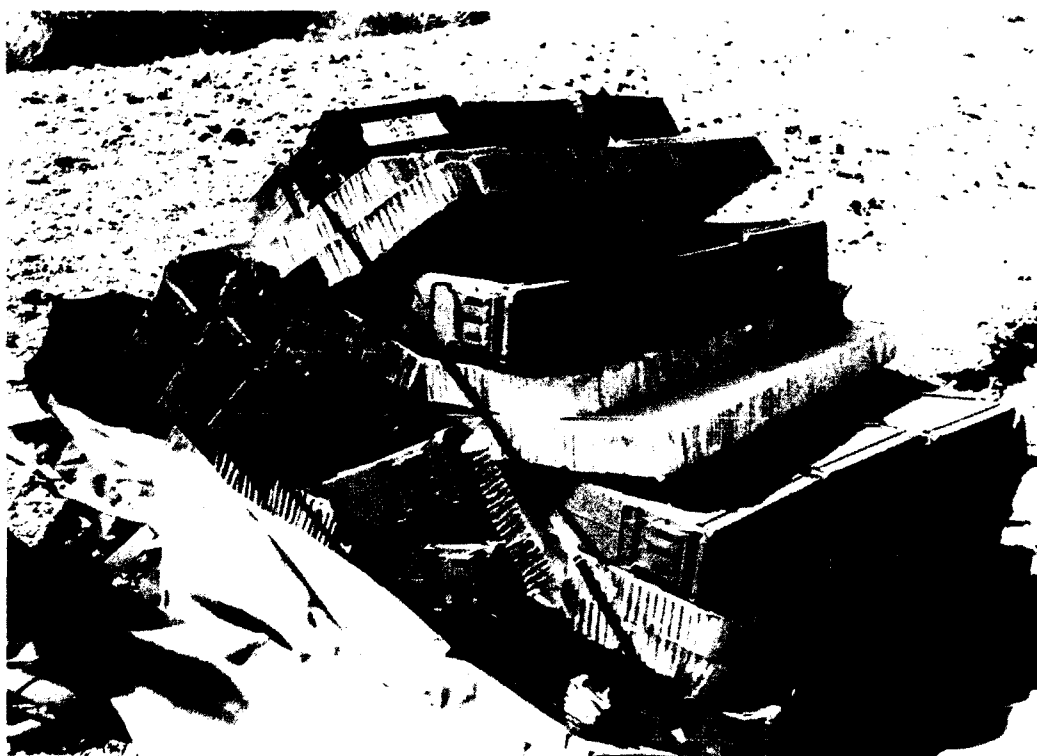
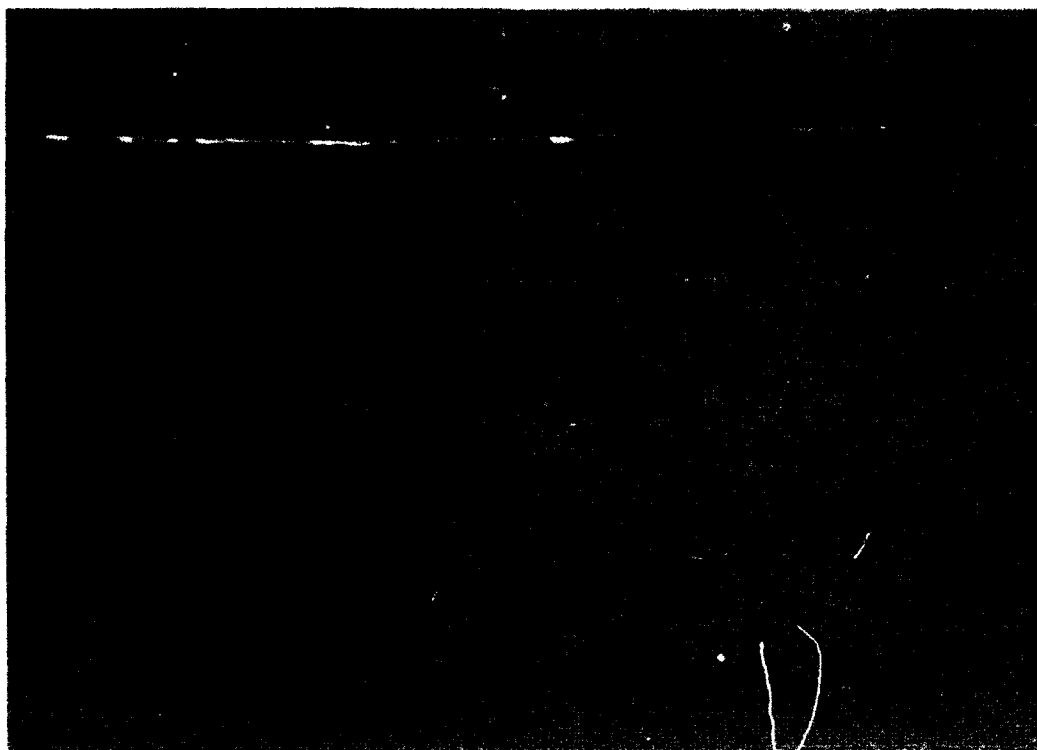


Figure C-1. PQT at Yuma Proving Ground, high velocity A-7A cargo sling

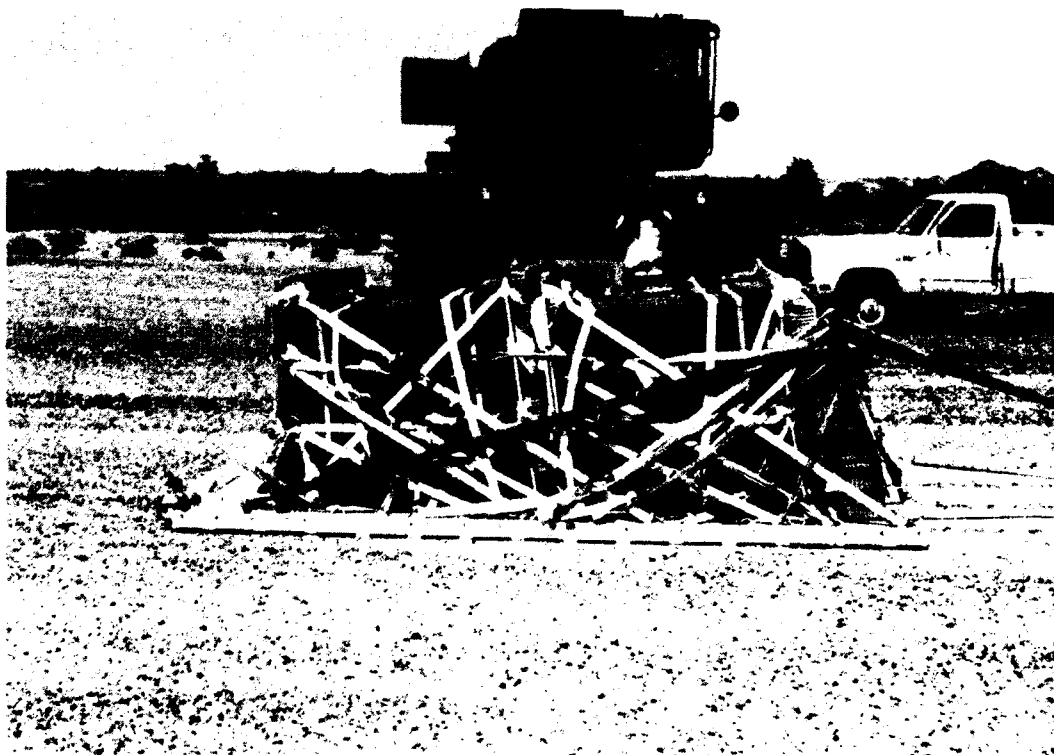
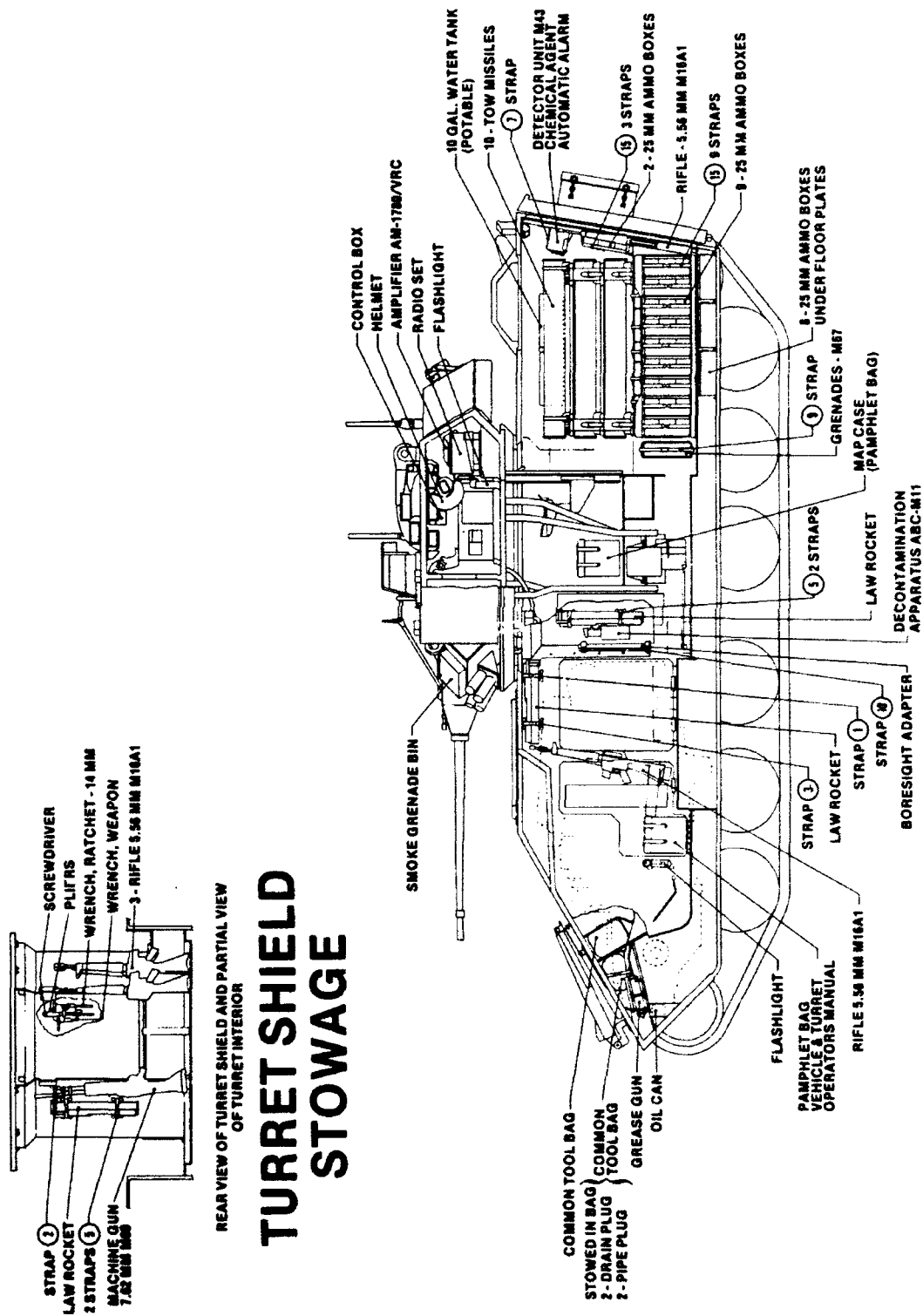


Figure C-2. PQT at Yuma Proving Ground, low velocity pallet configuration

## **APPENDIX D**

### **STOWAGE FOR 25 mm AMMUNITION IN BRADLEY FIGHTING VEHICLE**



## RIGHT INTERIOR STOWAGE

Figure D-1. Turret shield and right interior stowage

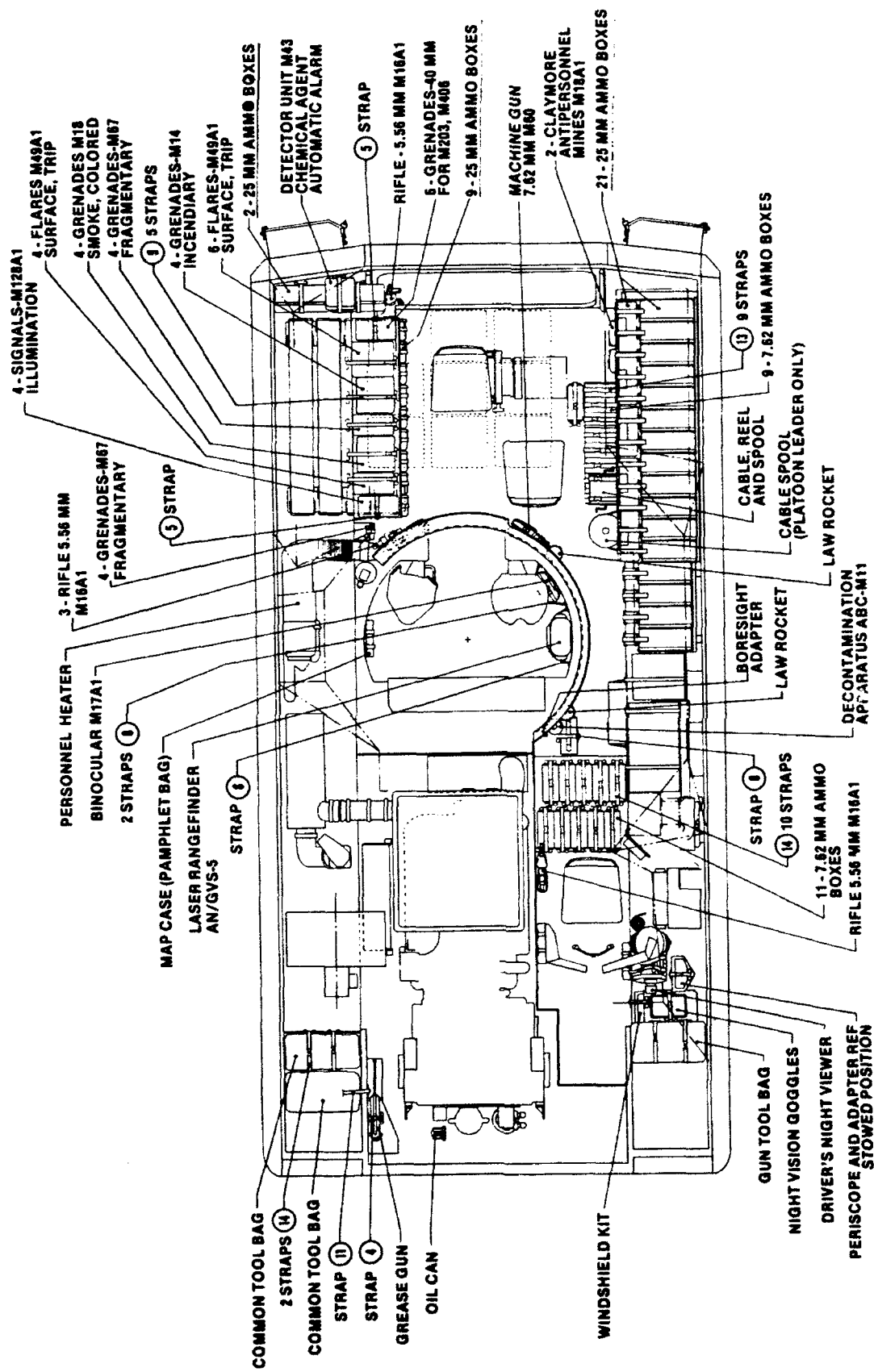
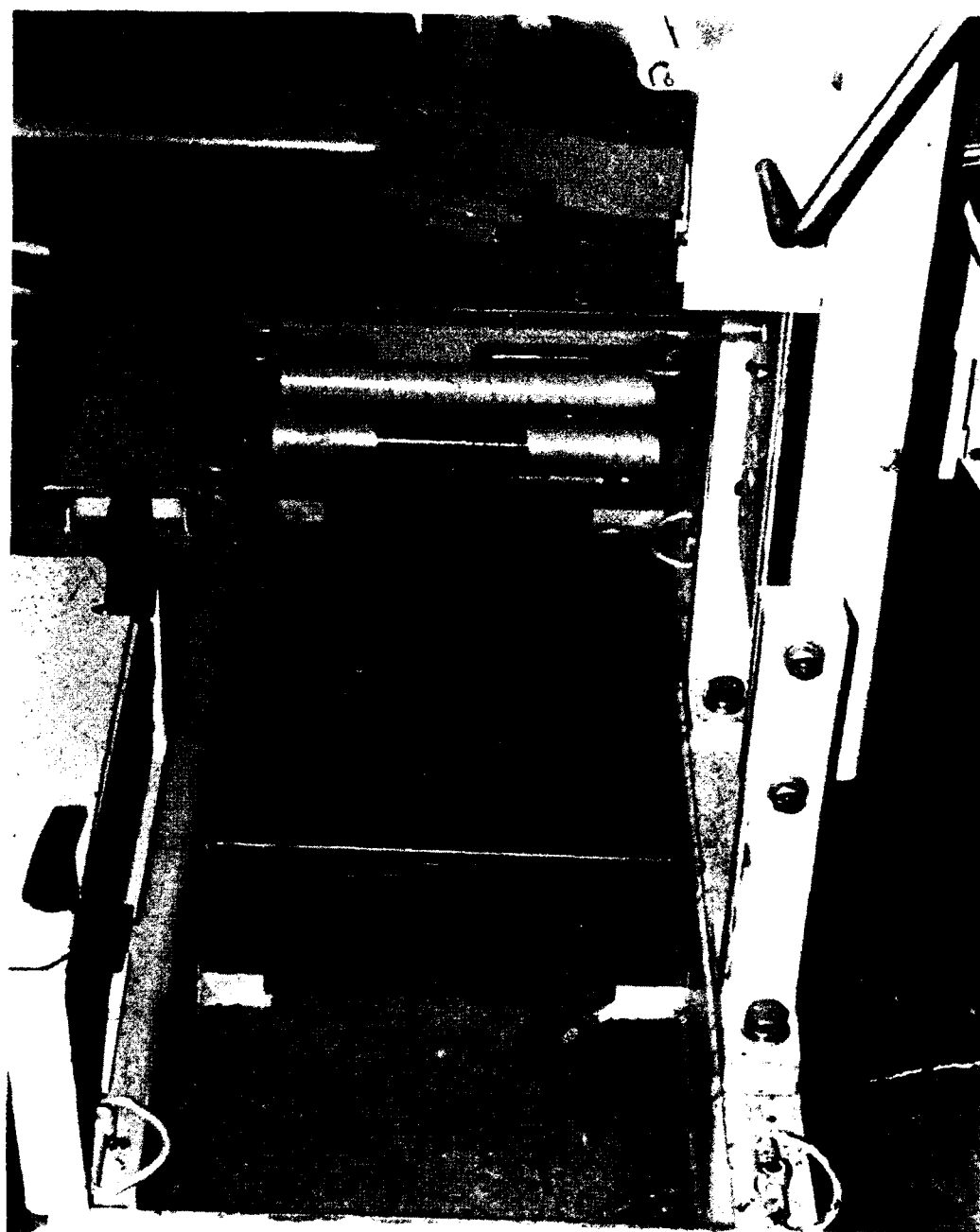


Figure D-2. Interior stowage, top view



TACOM RELEASED AN ECP TO REMOVE FIN  
DIVIDERS EXCEPT THE ONES NEXT TO THE  
TORSION BAR TO ACCEPT PA125 CONTAINER

Figure D-3. Interference between fin divider and PA 125  
on floorboard stowage compartment



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